

NASA TECH BRIEF

Lewis Research Center



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Wide-Range Nuclear Magnetic Resonance Detector

An all solid state (predominantly integrated circuit) nuclear magnetic resonance (NMR) detector has been built that is both compact and easy to use. In addition, the system uses a coaxial transmission line between the completely passive probe and the electronics package. This makes it possible to locate the probe a considerable distance from the electronics package as would be required in the case of cryogenic magnets. Although originally designed for measuring field strength to 20 teslas in cryogenically cooled magnets, the extremely low noise and high sensitivity make this detector applicable to nearly all types of analytical NMR measurements. It can also be used to advantage in a variety of situations, such as in high temperature or radiation environments that would be harmful to the main body of the electronics.

The phenomenon of nuclear magnetic resonance is based on the fact that a nucleus with nonzero spin, when placed in a magnetic field, precesses about the field direction. The rate of precession depends both on the magnitude of the field and on the characteristics of the nucleus itself (its dipole moment). For each nuclear species, there exists a simple linear relation between the precessional frequency f and the field strength H ;

$$f = \frac{\gamma}{2\pi} H$$

The parameter γ , commonly called the gyromagnetic ratio, has a unique value for each nuclear species and has been determined for all species with great precision. Therefore, a determination of the precessional frequency f gives a direct measure of the magnetic field H experienced by the nuclei.

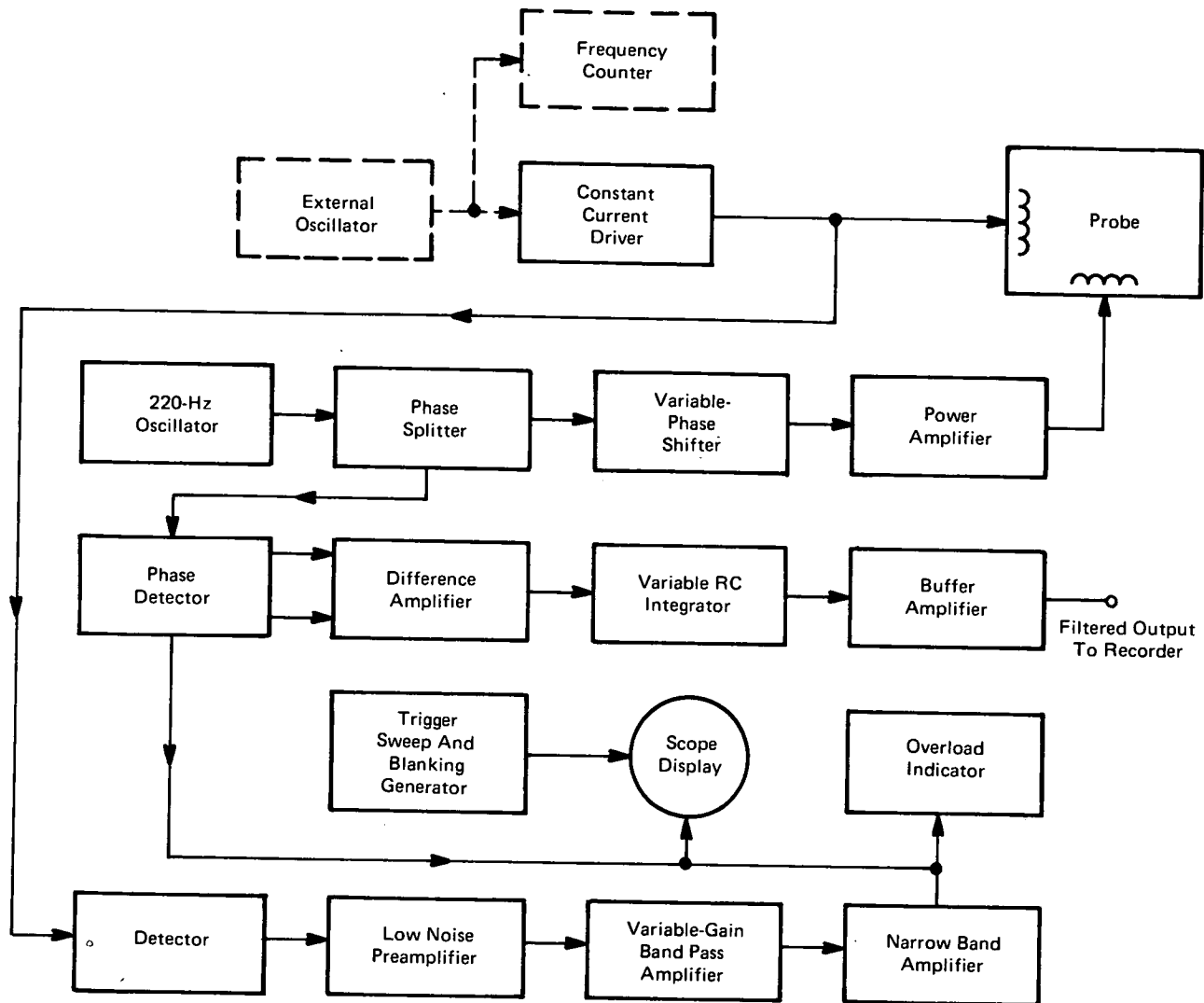
In practice, the precessional frequency is determined by subjecting a sample containing the nuclei to electromagnetic radiation such as that produced by an rf coil.

When the frequency of the electromagnetic radiation is equal to the precessional frequency, a resonant condition exists wherein an exchange of energy is induced between the nuclei and the radiation field. This energy loss can be detected as a slight increase in the loading on the rf coil. A measurement of the frequency at which the resonance is produced thus provides a direct determination of the magnetic field strength.

It should be noted that when NMR is used as a magnetic-field measuring device, the degree to which the resonant condition registers in the detection electronics has no effect on the accuracy of the field measurement. The quantity that is ultimately measured is the rf frequency, not the signal produced by the resonated nuclei. One need only be able to recognize that a resonance does in fact occur and to note the frequency in order to assign a value to the field strength. The precision of the measurement is dependent only on the frequency determination and on the degree to which the gyromagnetic ratio is known, which is usually five significant figures.

The system which was developed is shown in the block diagram. It is of the single rf coil type, with the nuclear sample located within the rf coil. A signal from an external rf oscillator is converted to a proportional rf current which is supplied to the tank circuit. This tank circuit consists of the probe coil, interconnecting coaxial cable, and the tuning capacitor located in the main electronics package. Also contained in the sensing head is a small Helmholtz coil which modulates the field at a 220 Hz rate to sweep through the nuclear resonance point. The absorption, detected as a 220 Hz modulation of the tank voltage, is amplified, filtered, and converted to a DC voltage using synchronous (phase) detection. An alternate output is provided on a built-in cathode ray tube display. This consists of the amplified signal displayed on a tune base locked to the modulating signal.

(continued overleaf)



Nuclear Magnetic Response Resonance (NMR) Detector System
Block Diagram

Notes:

1. The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price \$3.00
(or microfiche \$0.95)

Reference: NASA-TN-D-6338 (N71-26908),
Wide-Range Nuclear-Magnetic-Resonance Detector
Using Integrated Circuits

2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B72-10478

Patent status:

No patent action is contemplated by NASA.

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